

COMDAT OMI STUDY: VERSION 1.0

on behalf of
Defence and Civil Institute of Environmental Medicine

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10 October 2001

ABSTRACT

This report includes supplemental and background material related to the development of the COMDAT OMI Style Guide for Navy Command and Control operations. The material is presented here in five chapters. Three chapters comprise background materials as follows: the purpose and outline of the COMDAT OMI Style Guide, a literature review, and a discussion of making the documents available on the World Wide Web. The remaining two chapters present respectively a discussion of Naval symbology and a discussion of identified Human Factors and Usability issues in specific command and control functions of a Halifax-Class Canadian Patrol Frigate (CPF).

RÉSUMÉ

Le présent rapport comprend des renseignements supplémentaires et de base liés à l'élaboration du guide de style COMDAT OMI destiné aux opérations de commandement et de contrôle maritimes. Les renseignements sont présentés en cinq chapitres dont trois comprennent les informations de base suivantes : un aperçu du guide de style COMDAT OMI et son but, une analyse documentaire et une discussion sur la communication des documents au moyen du World Wide Web. Les deux autres chapitres exposent respectivement une discussion sur la symbologie navale et une discussion sur les facteurs humains connus et les aspects de l'utilisabilité pour des fonctions précises de commandement et de contrôle d'une frégate canadienne de patrouille (FCP) de la classe Halifax.

EXECUTIVE SUMMARY

The COMDAT OMI Style Guide was created to provide a common framework for new developments in Command Decision Aids. Specific supplemental and background was required to support the development of the COMDAT OMI Style Guide. The supplemental and background materials are presented in five chapters in this report as follows:

- 1 Statement of Purpose. Presents a statement of the purpose of the COMDAT OMI Style Guide development and an outline of the style guide.
- 2 Literature Review. Presents an annotated literature review of a variety of documents that apply to the COMDAT I development.
- 3 Naval Symbolology. Presents a discussion of requirements for Naval symbolology, including concept proposals for MSDF symbolology.
- 4 Identified Usability Issues. Presents a discussion of a detailed report that identifies Human Factors and Usability issues in the command and control of a Halifax-class CPF. The complete document is available in a separate document prepared by Unger Campbell and Associates for DCIEM. The complete report is entitled *Halifax-Class Canadian Patrol Frigates: Command and Control Usability Recommendations* (Gweneth Unger Campbell, Unger Campbell and Associates, 24 August 2001).
- 5 Usability on the World Wide Web. This chapter recommends the most effective way to post the COMDAT OMI Style Guide on the World Wide Web and discusses enhancements to the document that will make it more usable in that format.

Each of the chapters in this report provides information that supports or enhances the COMDAT OMI Style Guide.

SOMMAIRE

Le guide de style COMDAT OMI a été créé pour servir de cadre commun aux nouvelles aides à la décision de commandement. Il a fallu des renseignements supplémentaires et de base pour appuyer l'élaboration du guide de style COMDAT OMI. Ces renseignements sont présentés en cinq chapitres dans ce rapport :

- 6 Exposé du but. Énonce le but de l'élaboration du guide de style COMDAT OMI et donne un aperçu de ce dernier.
- 7 Analyse documentaire. Présente l'analyse documentaire d'une variété de documents qui s'appliquent à l'élaboration du COMDAT OMI.
- 8 Symbologie navale. Fournit une discussion sur les besoins de symbologie navale, sans oublier les propositions de concepts concernant la symbologie des forces navales d'autodéfense.
- 9 Aspects d'utilisabilité déterminés. Expose une discussion sur un rapport détaillé qui identifie des facteurs humains et des aspects d'utilisabilité relatifs au commandement et au contrôle d'une FCP de la classe Halifax. Les renseignements complets sont fournis dans un document séparé, rédigé par Unger Campbell and Associates pour le compte de l'IMED. Le rapport complet s'intitule *Halifax-Class Canadian Patrol Frigates: Command and Control Usability Recommendations* (Gweneth Unger Campbell, Unger Campbell and Associates, 24 août 2001).
- 10 Utilisabilité sur le WWW. Ce chapitre recommande la manière la plus efficace pour présenter le guide de style COMDAT OMI sur le World Wide Web et traite des améliorations à apporter au document pour rendre celui-ci utilisable sur le Web.

Chaque chapitre de ce rapport fournit des renseignements qui appuient ou mettent en valeur le guide de style COMDAT OMI.

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INTRODUCTION

The purpose of creating a new Canadian style guide is to provide design guidance for the Operator-Machine Interface (OMI) of the Command Decision Aiding Technology (COMDAT) technology demonstrator. The COMDAT I project has been undertaken to research and demonstrate MSDF technologies and to carry out Human Factors studies to support evolutionary upgrades to the Halifax-Class command and control system.

In the long term, the COMDAT OMI Style Guide will apply to new technology that will be deployed in the fleet. Accordingly, the style guide is designed to incorporate each of the following considerations:

- Adherence to current forms of doing business
(to take advantage of the current fleet knowledge base)
- Address current Human Factors knowledge and practices
(to provide enhancements using new information)
- Provide for growth
(to permit integration of new technology and techniques)

The intended users of the style guide are, in the short term, those Defence R & D Canada personnel who are involved in the development of the COMDAT Technology Demonstrator. The ultimate users of the technology will be the fleet personnel, although they will not use the style guide *per se*.

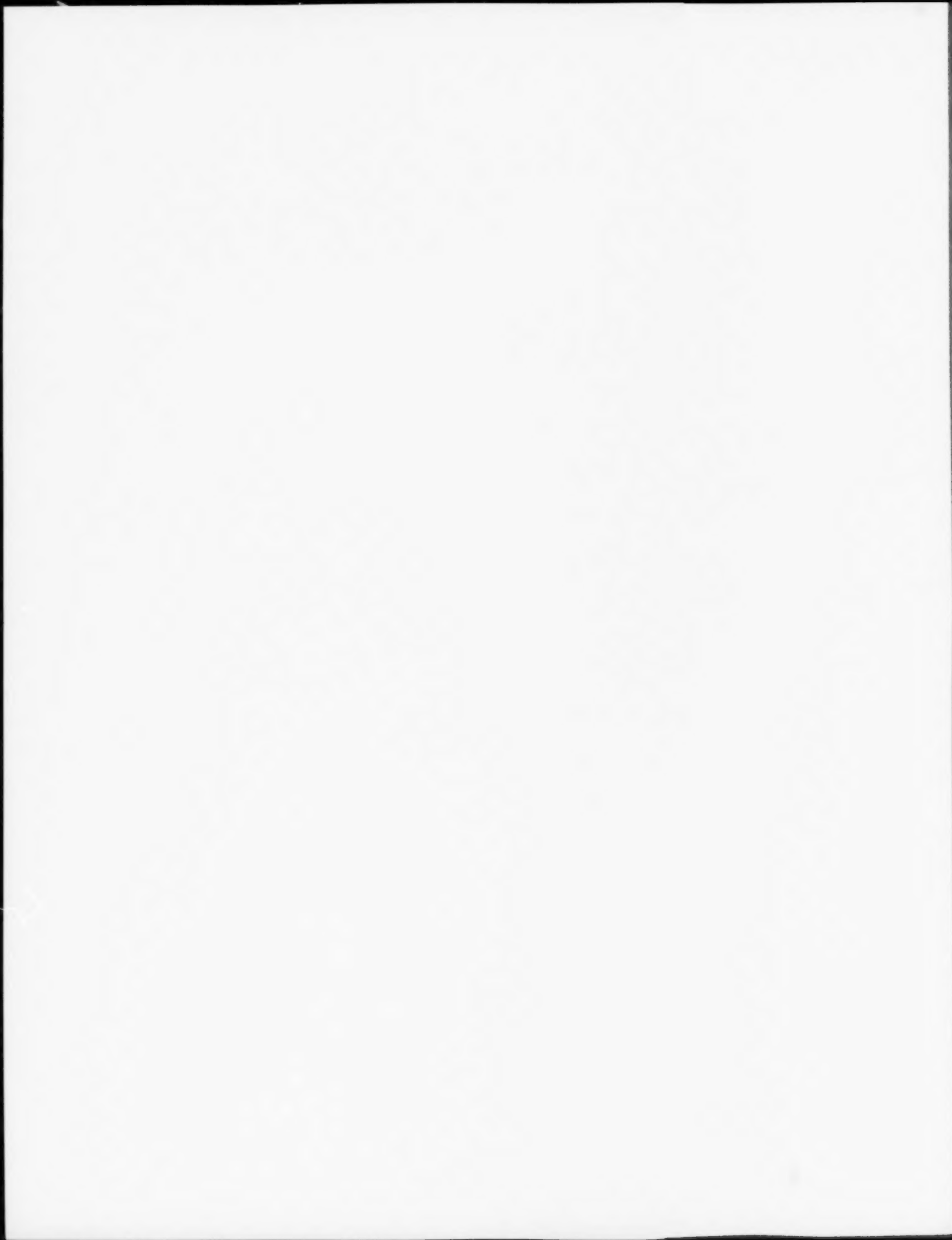
In support of the development of the COMDAT OMI Style Guide several reports were commissioned. Those reports include discussions of symbology, Human Factors and usability, and a literature review. The reports also included a statement of intent (Purpose and Outline of the COMDAT OMI Style Guide), and a discussion of issues relevant to making the documents available on the World Wide Web. These supporting documents are not included in the COMDAT OMI Style Guide but instead are made available in this report.

The COMDAT OMI Style Guide is available as a Defence and Civil Institute of Environmental Medicine (DCIEM) document. The reference for the document is presented below:

- *Command Decision Aiding Technology (COMDAT) Operator-Machine Interface (OMI) Style Guide* (Version 1.0). (15 August 2001). Gweneth Unger Campbell, Unger Campbell and Associates, PWGS Contract Number W7711-007659/001/TOR, DCIEM.

This report is divided into five chapters. The five chapters are as follows:

- 1.0: OMI Study: Purpose and Outline of the COMDAT OMI Style Guide
- 2.0: COMDAT OMI Study: Literature Review
- 3.0: Naval Command and Control Symbology Including Multi-Sensor Data Fusion (MSDF)
- 4.0: Discussion of Identified Human Factors and Usability Issues in the Halifax-Class Canadian Patrol Frigate
- 5.0: COMDAT OMI Study: Making the Documents Available on the World Wide Web



1.0

OPERATOR-MACHINE INTERFACE (OMI) STUDY PURPOSE AND OUTLINE OF THE COMDAT OMI STYLE GUIDE

1.1 INTRODUCTION

This chapter is divided into two sections as follows:

- 5.1 Introduction
- 5.2 Table of Contents for the Style Guide

1.1.1 Overview. A new style guide was the primary product of this contract. The purpose of creating a new style guide is to provide design guidance for the Operator-Machine Interface (OMI) of the Command Decision Aiding Technology (COMDAT) technology demonstrator. The COMDAT I project has been undertaken to research and demonstrate Multi-Sensor Data Fusion (MSDF) technologies and to carry out Human Factors studies to support evolutionary upgrades to the Halifax-Class command and control system.

The style guide is designed to present a judicious blend of the following:

- Adherence to current forms of doing business
(to take advantage of the current fleet knowledge base)
- Address current Human Factors knowledge and practices
(to provide enhancements using new information)
- Provide for growth
(to permit integration of new technology and techniques)

1.1.2 Intended Users. The intended users of the style guide are, in the short term, those Defence R & D Canada personnel who are involved in the development of the COMDAT Technology Demonstrator. Ultimately the style guide must support optimum usability for the operators of the systems.

1.1.3 Approach. The approach to developing a style guide included the following reviews and observations:

- related style guides
- related documentation
- observations of actual operations

The combination of reviews resulted in Unger Campbell's enhanced domain knowledge and increased familiarity with current style guides. Current defence style guides were used to guide the development of the new style guide. Observation of actual operations was invaluable in defining those elements of style that are appropriate for the COMDAT I development and those elements that are not appropriate for the COMDAT development.

Using an existing style guide as a basis for the new style guide was the most effective means to meet the goals of this contract. Upon discussion with DCIEM (See Meeting Minutes for 13 and 14 March 2001; line item #5) the choice of existing style guides was short-listed to the following:

- Global Command and Control System – Maritime (GCCS-M)
- Combat Systems Functional Allocation Board (CSFAB) Human-System Interaction
- CSUM Manual
- MS Windows®
- 1472F

1.1.4 Basis for the Style Guide. Unger Campbell and DCIEM determined that the GCCS style guide, as represented in the Theater Battle Management) Human Computer Interface (HCI) Specification (Version 1.1) is the most appropriate base for the new style guide. The decision was reached upon consideration of the following:

- *CSUM Manual and 1472F.* These documents are not appropriate bases for the new style guide. Although they contain valuable information, they are not intended to serve as style guides. They have neither the appropriate framework nor the necessary information to serve as a foundation for the new style guide.
- *MS Windows®.* The MS Windows style guide is an appropriate resource, particularly for its attention to general Human-Computer interactions. However, the MS Windows style guide is not optimized for defence or real-time applications.
- *CSFAB.* The CSFAB style guide is a style guide and does address specific design guidance for combat systems. As such, it takes into account features unique to combat systems such as display of range and bearing, threat, track selection, symbology, etc. It also includes specific defence categories such as icons, maps, and tactical plots. It is a valuable resource. The CSFAB guide is under development and, as of this writing, several sections have yet to be completed. Appropriate sections from CSFAB are included in the new style guide.
- *GCCS-M.* The GCCS-M style guide has been incorporated into the Theater Battle Management (TBM) Human Computer Interface (HCI) Specification, Version 1.1. The TBM Specification forms the basis for the new style guide being developed here. The TBM Specification includes a wide range of style guide issues, and addresses many features unique to combat systems.

1.1.5 Format for the Style Guide. Unger Campbell combined the relevant features of the CSFAB, TBM, and 1472F guidance into a single document and edited the guidance for the specific COMDAT purposes. The edited version includes added guidance where appropriate, inclusion of new information as available, and deletion of elements which are inappropriate for the COMDAT application.

1.1.6 Commercial Styles. The TBM and CSFAB style guides specifically state that Motif® widgets are prescribed for all applications. The style of many defence applications has historically been the OSF/Motif style. There are two compelling reasons, discussed below, to shift the focus to MS Windows style.

First, in the non-military environment the *de facto* style for most applications has become MS Windows. One intent of the COMDAT OMI Style Guide is to create a guide that builds on the end-users' previous knowledge of MS Windows styles and widgets. The choice to build on the base knowledge of the operators does not assume that the operators are advanced computer users. Building on base knowledge does assume that if the operators are familiar with other MS Windows applications then the usability of the new technology will be enhanced due to consistency among the applications.

Second, the shift of focus to MS Windows acknowledges the tendency of all branches of the defence community to scale back acquisition costs. Using the MS Windows style broadens the availability of suitable COTS software. Mental integration is easier for the operators when COTS products, customized products, and unique products all consistently follow the same style.

It is not cost-effective, or useful, to reproduce commercial style guides in the new style guide. Rather than to reproduce the MS Windows style guide and integrate it into the new style guide the developers are urged to refer to the MS Windows Style Guide for appropriate detail. MS Windows guidance is generalized and so not all of the guidance is suitable for COMDAT applications. Examples of unsuitable guidance include options to alter colors freely or to change window locations and sizes at will. Identified issues such as these are addressed in the COMDAT OMI Style Guide.

1.2 TABLE OF CONTENTS FOR THE STYLE GUIDE

- 1.2.1 Introduction.** The initial table of contents for the new style guide was a combination of the CSFAB and TBM guides, with an added Usability Annex. The final *COMDAT OMI Style Guide* included more subject matter than was initially planned. The high-level contents of the final *COMDAT OMI Style Guide* is presented here. Upon discussion between Unger Campbell and DCIEM, it was also decided that the Usability Annex would be more useful if presented as a separate document. The Usability Annex is available in a DCIEM report entitled: *Halifax-Class Canadian Patrol Frigates: Command and Control Usability Recommendations* (Gweneth Unger Campbell, Unger Campbell and Associates, 24 August 2001).

The resources that were considered in the development of the *COMDAT OMI Style Guide* varied from the very specific to the general. The three fundamental source documents were the TBM guide, CSFAB, and 1472F. The TBM guide proved to be a particularly complete resource, although it does not include focus on Icons, Maps and Tactical Plots, etc., which are featured in the CSFAB guide. Icons, Maps, and Tactical plots are of particular importance to COMDAT systems and received commensurate attention in the new style guide. The guidance of 1472F tends to be generalized and was included in *COMDAT OMI Style Guide* as appropriate.

In addition to the three fundamental source documents the new style guide incorporates Unger Campbell's professional knowledge of usability in general, Maritime operations, and Command and Control. That professional knowledge was further supplemented with information gathered from the literature review and from MS Windows sources. All of the information is reflected in the *COMDAT OMI Style Guide*.

1.2.2 COMDAT OMI Style Guide Table of Contents.

The table of contents section numbers are as they appear in the *COMDAT OMI Style Guide*.

- 1.0 Introduction
- 2.0 Design Decision Filters
- 3.0 Source Documents
- 4.0 Input Devices
- 5.0 Windows
- 6.0 Design Guidance
- 7.0 Windows Navigation and Selection
- 8.0 Controls
- 9.0 Menus
- 10.0 Windows States, Components, and Operations
- 11.0 Security and Simulation
- 12.0 Data Display and Entry
- 13.0 Special Functions and Formats
- 14.0 Graph Display
- 15.0 Tactical Graphics
- 16.0 Maps and Situation Displays
- 17.0 Colour

- Appendix I: Highlights of the COMDAT OMI Styles
- Appendix II: Bibliography
- Appendix III: NTDS Symbolology
- Appendix IV: Windows Colours
- Appendix V: Tactical Display Graphics
- Appendix VI: Acronyms Used in this Document

2.0

OPERATOR-MACHINE INTERFACE (OMI) STUDY LITERATURE REVIEW

2.1 INTRODUCTION

The intent of the literature review reported here was to ensure that DCIEM and Unger Campbell are both cognizant of new research and directions that might be applicable to the usability of the developing COMDAT system. A second intent of the literature review was to provide a sense of the potential breadth of scope for future development. While the future of technology cannot be predicted with any accuracy it is essential that a style guide not restrict the creativity of the developers now or in the foreseeable future.

Dr. Campbell conducted an initial review of the following documents. The first three documents in the following list are associated with Task 3.1.5 (Review of the Human Factors Reports on the ORO position) of the Statement of Work (SOW).

This chapter is divided into three sections as follows:

- 2.2 Introduction**
- 2.2 Annotated Document List**
- 2.3 Demonstrations**

2.2 ANNOTATED DOCUMENT LIST

- 2.2.1 Bryant, D. J. and Webb, R.D.G. (January, 1999). Literature Survey for Issues in Naval Decision Support: Phase II. Humansystems, Inc.

Annotation: The literature survey addresses issues and models in decision support. It is particularly valuable as a background document.

- 2.2.2 Campbell, Gweneth U., Ph.D. [Unger Campbell and Associates]. (January 1997). NORAD [North American Aerospace Defense] R/SAOC [Region/Sector Air Operations Centres] Modernization Project: Human Factors Usability Review. (Report No. 96-CR). Department of National Defence, Contract #W7711-6-7289/001/SRV, Defence and Civil Institute of Environmental Medicine.

Annotation: The report on NORAD R/SAOC usability issues includes a wealth of information related to Command and Control, particularly air defence. Where applicable, identified issues and recommendations from this review of NORAD usability issues were incorporated into the new style guide and into a DCIEM report entitled: *Halifax-Class Canadian Patrol Frigates: Command and Control Usability Recommendations*. (Gweneth Unger Campbell, Unger Campbell and Associates, 24 August 2001).

- 2.2.3 Campbell, Gweneth U., Ph.D. [Unger Campbell and Associates]. (March 1997). Human Factors Assessment of Air Defence Anti-Tank System (ADATS) Operators' Stations. Contract #W8477-6-CD02/01/SRV. Department of National Defence,

Annotation: The ADATS report includes documentation of usability issues related to Command and Control, particularly in air defence. Where applicable, identified issues and recommendations were incorporated into the new style guide and into a DCIEM report entitled: *Halifax-Class Canadian Patrol Frigates: Command and Control Usability Recommendations* (Gweneth Unger Campbell, Unger Campbell and Associates, 24 August 2001).

- 2.2.4 Campbell, Gweneth U., Ph.D. (January 1999). NORAD [North American Aerospace Defense] R/SAOC [Region/Sector Air Operations Centres] Modernization Project. Assessment of Air Defence Symbolology Sets. Unger Campbell and Associates.

Annotation: An identified issue for the OMI Study is the use of symbolology for a variety of purposes. The document reported here presents an assessment of Air Defence Symbolology Sets. While the results are not immediately applicable to the OMI Study, the lessons-to-be-learned were incorporated into the new style guide, as appropriate.

- 2.2.5** Cardoso, Kim and Murphy, Elizabeth D., (Eds.). (1995). *Human Factors in the Design and Evaluation of Air Traffic Control Systems (Final Report)*. DOT/FAA/RD-95/3; DOT-VNTSC-FAA-95-3. U.S. Department of Transportation, Federal Aviation Administration.

Annotation: The report on Human Factors in the design and evaluation of Air Traffic Control (ATC) systems contains considerable ATC-related Human Factors issues. These issues include information processing, auditory perception and speech and Human-Computer Interface issues. The report includes an addendum that presents research in color displays that proved to be a valuable resource for the new style guide.

- 2.2.6** Decision Support Displays for Military Command Centers. Enabling Knowledge-Centric Warfare for Fleet Decision Makers. Human systems IAC Gateway, Vol. 11(4).

Annotation: The decision-support report addresses the TADMUS project and its successors. The report concludes that the fleet decision-makers are faced with too much data and not enough information, the systems are not designed to support the decision makers, and reduced manning requirements will exacerbate the problem. The report provides valuable background for the OMI Study. In particular, the report describes the decision-making context for the COMDAT system.

- 2.2.7** Duquet, Jean-Rémi (Dr.) and Michaud, Guy (Dr.). (27 April 2000). Advanced Shipboard Command and Control Technology (ASCACT) Development of an Application Demonstration Platform (ADP) for Multi-source Data Fusion (MSDF). MSDF ADP User's Manual

Annotation: The MSDF ADP User's Manual provides technical information for the systems operators. In particular, it is a manual for the development team members who are controlling the MSDF application under test. Its utility to the OMI Study was to provide technical background rather than to contribute to usability or style guide issues directly.

- 2.2.8** Eddy, M.F. [H.D. Kribs Instructional Science and Development, Inc.] and Cowen, M. B. [SSC San Diego] (March 1999). Cognitive and Behavioral Task Implications for Three-Dimensional Displays and in Combat Information/Direction Centers. (Technical Report 1792). SPAWAR Systems Center, San Diego.

Annotation: This document presents an investigation of how information, if presented in three-dimensions, could contribute effectively to the operators' understanding of a battlespace. As with other documents cited here, this document provides useful background. Usability issues surrounding these new display technologies were considered in the development of the COMDAT OMMI Style Guide and the Usability Report *Halifax-Class Canadian Patrol Frigates: Command and Control Usability Recommendations*.

- 2.2.9** FAA Aircraft Certification Human Factors and Operations Checklist for Stand Alone GPS Receivers (TSO C-129 Class A). Research and Special Programs Administration, Volpe National Transportation Systems Center.

Annotation: The FAA checklist addresses task-related issues; many of which are similar to those confronting the ORO. The focus of the document is on testing the usability of stand-alone GPSs rather than creating a usable system. Because of the differences in focus between a style guide and a checklist, the checklist had limited utility in the development of the COMDAT OMI Style Guide.

- 2.2.10** Gillian, Douglas J.; Hollands, J.G.; and Carswell, C. Melody. (March 1998). Guidelines for Presenting Quantitative Data in HFES [Human Factors and Ergonomics Society] Publications. *Human Factors*, Vol 40 (1), pp 28-41.

Annotation: This guideline for presenting quantitative data is intended to guide the presentation of quantitative data for paper-based publications, rather than for presentation of information on display screens. However, there are specific rules that address the presentation of quantitative data, regardless of the medium of display. This resource was considered in the development of the COMDAT OMI Style Guide. The guidance presented in this document should be used to supplement the guidance presented in the COMDAT OMI Style Guide.

- 2.2.11** *Handbook 5: Guidelines for Maritime Information Management*. (19 April 1997). Command, Control, and Communications Committee, Issue 2.1.

Annotation: Handbook 5 is a valuable source of both detailed and context information for the OMI Study.

- 2.2.12** Hollands, J.G.; Cassidy, H.A.; McFadden S., [DCIEM] and Boothby, R. [Computing Devices Canada] LCD versus CRT Displays: A Comparison of Visual Search Performance.

Annotation: This document compares LCD and CRT displays in the context of a visual search task. The inclusion of a comparison of LCD and CRT displays in the background material for the OMI Study provides further detail concerning potential future directions for display hardware. The impact of the display hardware on usability was considered in the development of the COMDAT OMI Style Guide.

- 2.2.13** Hollands, J.G and Dyre, Brian P. (2000). Bias in Proportion Judgment: The Cyclical Power Model. *Psychological Review*, Vol. 107 (3) pp 55-524.

Annotation: The report on bias in judgments provides background information for issues in decision-making, particularly for people's ability to judge proportions. It is useful as background material COMDAT I development if the operators are required to judge proportions. Technology demonstrators, and other development efforts, may strive to create displays that reduce sources of error that negatively impact the decisions made by the operators.

- 2.2.14** Klein, Gary, Ph.D. (15 September 2000). Con-Fusion Algorithms. Klien Associates, Inc.

Annotation: The Con-Fusion Algorithm report describes a variety of issues centered on the efficacy of Multi-Source Data Fusion (MSDF). The Con-Fusion Algorithm report was written with reference to the ORO in Halifax Class Frigates and so provides particularly salient background information to the OMI Study. The Con-Fusion Algorithm report does not purport to solve the myriad of issues it presents, but it does emphasize the need to ensure that any implemented MSDF algorithms will result in improved performance.

- 2.2.15** Kubeck, K.A. (1999). CPF Operations Room HCI Deficiencies Documented in the Maritime Operational Deficiencies List (U). DCIEM TM 1999-121 Toronto, Ontario. Defence and Civil Institute of Environmental Medicine. SECRET

Annotation: This deficiencies report contains valuable usability information that was incorporated into the style guide. Unger Campbell recommends that the information in this report be taken into consideration for Halifax-Class CPF CCS upgrades.

- 2.2.16** Marcus, Aaron; Smilonich, Nick; and Thompson, Lynne. (1995). *The Cross-GUI Handbook for Multiplatform User Interface Design*. Reading, MA. Addison-Wesley.

Annotation: The Cross-GUI Handbook for Multiplatform User Interface Design includes a comparison among OSF/Motif, MS Windows, Macintosh, NeXTSTEP, and Presentation Manager. The handbook proved useful for a concept-level understanding of differences but was not useful at the detail level because of changes in interface standards and designs since 1995.

- 2.2.17** Maritime Command NOSTP 22 (A). (18 February 1997). Naval Operations School Training Publication.

Annotation: This training document served two functions for the purposes of the OMI Study. First, the training document provides insight into the tasks and operations of the ORO. The insight obtained through the training manual includes details of the OROs' tasks and attention requirements. Secondly, the training document provides insight into a portion of the ORO training. All of this information contributed to make the COMDAT OMI Style Guide appropriate to the requirements and missions of the end-users.

- 2.2.18** Matthews, M.L. and Webb, R.D.G. (10 March 1999). Validation of the Cognitive Task Analysis (CTA) for the Halifax-Class ORO. *Humansystems, Inc.*

Annotation: As with the cognitive task analysis, the validation of the cognitive task analysis provides useful background into the functions and tasks of the ORO. Differences between the cognitive task analysis and the validation of the cognitive task analysis provide a more accurate picture of the OROs' tasks and priorities. These tasks and priorities helped to direct the COMDAT OMI Style Guide.

- 2.2.19** Matthews, Michael L.; Webb, Robert D.G.; and Bryant, David J. (10 March 1999). Cognitive Task Analysis of the Halifax-Class Operations Room Officer, Volume 1 and Annexes. *Humansystems, Inc.*

Annotation: The cognitive task analysis in the *Humansystems* report provides a useful background into the functions and tasks of the ORO. The information provided helps to achieve an understanding of the ORO position and also points to information requirements that contributed to the style guide.

- 2.2.20** McKay, Everett. (1999). *Developing Interfaces for Microsoft Windows*. Microsoft Press.

Annotation: Developing Interfaces for Microsoft Windows has useful concept-level information for designers and details regarding how to implement the graphic user interface. The book includes a CD-ROM containing sample user interface guidelines and utility programmes. This reference was used to confirm MS Windows guidance particularly where it conflicts with OSF/Motif guidance. The reference is a valuable resource, especially for interface designers.

- 2.2.21** Michaud, Guy (Dr.) and Duquet, Jen-Rémi. (Dr.). (28 April 2000). Advanced Shipboard Command and Control Technology (ASCACT) Development of an Application Demonstration Platform (ADP) for Multi-Source Data Fusion (MSDF). MSDF Training Package [Slide presentation].

Annotation: The slide presentation on ASCACT includes the highlights of the ASCACT ADP MSDF project. The slides were created for the benefit of those personnel who will operate the test trials. The presentation provided background and context for the OMI Study but did not contribute directly to the COMDAT OMI Style Guide.

- 2.2.22** Michaud, Guy (Dr.) and Duquet, Jen-Rémi. (Dr.). (28 April 2000). Advanced Shipboard Command and Control Technology (ASCACT) Development of an Application Demonstration Platform (ADP) for Multi-Source Data Fusion (MSDF). MSDF ADP System Overview. [Slide presentation].

Annotation: This slide presentation provides the highlights of the MSDF ADP from the viewpoint of systems engineering. The presentation provided background and context for the OMI Study but did not contribute directly to the COMDAT OMI Style Guide.

- 2.2.23** Michaud, Guy (Dr.) and Duquet, Jen-Rémi. (Dr.). (28 April 2000). Advanced Shipboard Command and Control Technology (ASCACT) Development of an Application Demonstration Platform (ADP) for Multi-Source Data Fusion (MSDF). Developing with the MSDF ADP (Part 1 and 2) [Slide presentation].

Annotation: These slide presentations address highlights of the systems engineering of the MSDF ADP. The presentation provided background and context for the OMI Study but did not contribute directly to the COMDAT OMI Style Guide.

- 2.2.24** *Microsoft Windows User Experience: Official guidelines for User Interface Developers and Designers.* (1999). Microsoft Press.

Annotation: *Microsoft Windows User Experience: Official guidelines for User Interface Developers and Designers* was invaluable in the development of the COMDAT OMI Style Guide. The reference was used to provide MS Windows guidance, particularly where the Windows conventions differ from OSF/Motif. Developers should use this reference as a supplement to the COMDAT OMI Style Guide.

- 2.2.25** Mil-Std-1472F. (23 August 1999). Department of Defense Design Criteria Standard: Human Engineering. Section 15.4: User-computer Interface.

Annotation: Mil-Std 1472 contains a section on User-computer Interface that is incorporated into the CSFAB and TBM style guides. Mil-Std. 1472F standards are incorporated into the new style guide.

- 2.2.26** Osaga, Glenn A. (1989). Human Factors Issues in Future Navy Workstation Development: Symposium Abstract. *Proceedings of the Human Factors Society 33rd Annual Meeting*,

Annotation: This human factors report is a collection of several papers that address, for the most part, methods of data-capture for the evaluation of workstations and displays. The information in the reports is beyond the scope of this project but is useful for the development teams.

- 2.2.27** Roy, Jean; Breton, Richard; and Paradis, Stéphanie. Human-Computer Interface for the Study of Information Fusion Concepts in Situation Analysis and Command Decision Support Systems. DREV.

Annotation: Operators (and designers) of Command and Control Systems need to create systems that support the users' management of information and maintenance of situation awareness. This study of information fusion concepts explores an "operational-like" human-machine interface prototype called Command Decision Support Interface (CODSI) and provides useful background information.

- 2.2.28** St. John, M., [Pacific Science and Engineering Group, Inc.] and Oonk, H. M. [M.B. Cowen Space and Naval Warfare System Center, San Diego]. (February 2000). Using Two-dimensional and Perspective Views of Terrain. (Technical Report 1815). SPAWAR Systems Center, San Diego.

Annotation: This document on using two-dimensional and perspective views of terrain presents experiments using various presentations of terrain. The report serves to highlight research into relatively new technology (three-dimensional views). Usability issues surrounding three-dimensional representations of data were considered in the development of the COMDAT OMI Style Guide.

- 2.2.29** Smallman, M.S.; St. John, M.; Oonk, H. M. [Pacific Science and Engineering Group, Inc.] and Cowen, M.B. [SSC San Diego]. (March 2000). Track Recognition Using Two-Dimensional Symbols or Three-Dimensional Realistic Icons. (Technical Report 1818). SPAWAR Systems Center, San Diego

Annotation: This document, on track recognition, reports on an investigation of the recognition of various types of icons and symbols, both in two- and three-dimensional presentations. As with other documents cited here that investigate three-dimensional technology, this document provides useful background. Usability issues surrounding these new display technologies were considered in the development of the COMDAT OMI Style Guide and a DCIEM report entitled: *Halifax-Class Canadian Patrol Frigates: Command and Control Usability Recommendations* (Gweneth Unger Campbell, Unger Campbell and Associates, 24 August 2001).

- 2.2.30** Webb, R.D.G. and McLean, D. N. (1997). Deficiencies in Command and Control Support to the Command Team in the Halifax Class (U). (DCIEM No. 97-CR-28). Contract No. W7711-6-7286-19, Guelph Ontario: Humansystems, Inc. CONFIDENTIAL

Annotation: This deficiencies report contains valuable usability information that was incorporated into the style guide. Unger Campbell recommends that the information in this report be taken into consideration for Halifax-Class CPF CCS upgrades.

- 2.2.31** Wickens, Christopher D. and Hollands, Justin G. (1999). *Engineering Psychology and Human Performance, Third Edition* [Selected chapters]. Prentice Hall, N.J.

Annotation: Relevant chapters in this reference contributed to the background information for the OMI Study.

2.3 DEMONSTRATIONS

During a visit to DCIEM Dr. Campbell was able to review the TADMUS demonstrator as well as slide presentations of other projects in development. The demonstrations provided a valuable starting point for the identification of usability issues in the COMDAT system.

3.0 NAVAL COMMAND AND CONTROL SYMBOLOGY INCLUDING MULTI-SENSOR DATA FUSION

3.1 INTRODUCTION

Effective Naval defence operations require that the operators of the Command and Control Systems (CCSs) have an unambiguous understanding of the tactical situation. The level of detail that is required to support excellent decision-making depends on the level of knowledge needed within the command and control hierarchy. Generally speaking, as one goes up the levels of command detailed information is combined to form a higher-level view. The focus of this chapter is the symbology required to support the level of information required by back row operators of a Halifax-class Canadian Patrol Frigate (CPF) CCS. The back row operators are the Operations Room Officer (ORO), the Surface Warfare Controller (SWC) and the Anti Submarine Warfare Controller (ASWC). This chapter addresses tactical display symbology for these operators and the symbology required to support Multi-Sensor Data Fusion.

One of the issues surrounding the presentation of data fused from multiple sensors is how to convey to the operator the certainty that a contact has been detected and that it is displayed accurately. In this chapter a user-centred perspective on the MSDF display symbology is discussed. Efforts to display a fused detection have frequently focussed on providing the operators with a computer-calculated estimate of the reliability of the information. In essence, the system uses an algorithm to estimate the combined certainty that the contact represents the ground truth. This chapter presents an approach to conveying certainty information to the operator that is similar to the traditional approach but the focus is instead on the operator. The traditional approach conveys the computer's calculation of certainty. The approach discussed here centres on providing information from the system that the operators need to know in order make their own estimates of certainty. The operators' estimates of certainty take into consideration the entire operational experience and training. Operators' estimates are based on their view of the tactical picture, their experience with the sensors, their defence experience, and their knowledge of the situation.

The tactical display is the heart of the information that the back row operators need in order to conduct the missions. The back row operators receive the tactical symbology from computer-identified contacts and from the identification efforts of the front row operators. The critical information received by the operators is not the data itself,

rather it is the information that the operators can derive from the data and use to enhance their mission effectiveness through knowledge of the situation.

This chapter discusses a number of issues regarding symbology including a proposal for designing MSDF symbology (Section 3.5).

This chapter is divided into six sections as follows:

- 3.1 INTRODUCTION**
- 3.2 SYMBOLS AND INFORMATION**
- 3.3 HUMAN AND COMPUTER MSDF IDENTIFICATION**
- 3.4 TESTING NEW SYMBOLOGY**
- 3.5 MSDF CONCEPT PROPOSAL**
- 3.6 SYMBOLOGY RECOMMENDATIONS**

3.2 SYMBOLS AND INFORMATION

Effective symbology must be consistent. Consistency is important on several levels within the Navy command structure. Navy operators frequently will have worked on more than one command and control system. Inter-operability within all of the systems results in fewer errors and reduced training requirements. Within a single command and control system consistency in symbols and coding results in the above benefits (fewer errors and reduced training) and also increases efficiency of communication for the entire combat team. Communication errors have been identified as a source of error and delay in command and control, negatively affecting mission effectiveness.

In order to develop new symbology or display symbols resulting from Multi-sensor Data Fusion (MSDF) technology the first step is to determine what information the back row operators required. It is not sufficient to assume that they require a view into the underlying technology; a view into the underlying technology may not be effective in building the tactical picture. Instead, an effort should be made to determine the type and level of knowledge that the operators require in order to use the information from MSDF effectively.

New symbology resulting from MSDF technology must be consistent with current naval symbology. By building on the conventions already learned regarding colour, shape, and alphanumeric codes for warfighting symbology the newly proposed symbology will require less training, and will not induce errors.

If radically new families of symbols are developed (e.g., three dimensional graphics) the MSDF symbols must be intuitive extensions of the basic symbology set. The operators' sense of intuitive consistency should be maintained regardless of the sophistication of the graphics.

3.3 HUMAN AND COMPUTER MSDF IDENTIFICATION

In Command and Control Systems (CCSs) a primary distinction is made between computer-identified contacts and human-identified contacts. This distinction is essential for a number of reasons, both tactical and legal. Symbology unique to MSDF must retain this distinction. Once a human operator has confirmed the MSDF contact and identification, then the symbol is changed to indicate that the contact is confirmed.

3.3.1 Referencing Raw Data. As part of creating an awareness of the tactical situation, the back row operators frequently confirm the contacts' characteristics by looking at the underlying raw data of the contact. The raw data are used to enhance the knowledge about a contact (for example, it may be used to confirm the size of the contact). Access to raw data or other information that the operator may use to enhance the tactical picture and operational knowledge should be supported in the MSDF display symbology. Symbology for MSDF should be simple yet should be enhanced with options that permit the operator to view the raw display directly. The symbology itself does not have to convey all of the background information. Instead, a "quick look" capability permits the operators to confirm information (for example, confirming the size of the contact object by viewing the raw radar return).

It is not an effective solution to provide a series of shadow symbols, indicating slight variations in the data acquired from each sensors. When multiple symbols are displayed, the operators spend an inappropriate amount of time and cognitive bandwidth clearing the display. Instead, the operators who place the symbology on the display (the front row operators) should be provided with a best-calculated decision and an option to review the data and select the best source with which to associate the symbology.

3.3.2 Literal Representations. Graphic capabilities are rapidly improving. Displays that are too compelling visually may induce errors unless absolute accuracy can be guaranteed. When graphic displays are too compelling, the graphic representations tend to be interpreted literally by human operators. The visual imagery used will affect the operators' interpretation of the ground truth. For example, a graphic that looks like a specific type of ship will tend to be interpreted as representing that type of ship even if the intent is to display a generic ship. When specific types of contacts require similar responses, there is utility to having similar appearances in the symbols. The solution is not to design more detailed representations. Instead, the design should use generic shapes if the symbols are intended to represent broad classes of contacts. Similarly, simple graphics should be used because they are easier and faster for humans to interpret than complex and detailed graphics.

3.3.3 Certainty.

3.3.3.1 Certainty of the Contact. The back row operators require a means to determine the certainty of MSDF-identified contacts. In current operations the back row operators confirm the certainty of a computer-identified contact by referring to a machine-calculated number displayed for each computer-identified contact. The results are interpreted as belonging to one of two categories as follows:

- Either the supposed contact is too ephemeral to consider and is mentally dismissed.
- The presence of the contact is certain enough to be considered in the tactical picture.

For tactical reasons all potential contacts must be responded to; fine distinctions to identify the strength of the supposed contact do not affect the tactical response. The tactical requirement to be aware of all potential contacts is important when considering the design of tactical symbology. The symbology codes need to reflect levels of certainty appropriate to operations. Operators do not mentally dismiss any computer-identified object that is at all likely to be a possible contact.

3.3.3.2 Certainty Symbology. Creating symbology for the MSDF-identified contacts presents several design challenges. Many of the design solutions attempt to indicate reliability of the information by a display of the results of a certainty calculation. The obvious coding to display a level of certainty produces cognitive effects that are diametrically opposed to the intent of the codes. Discussions of size and brightness codes are presented below as examples:

Size. It is not effective to increase the size of the track symbol to indicate that the contact is more certain. The reasons are related to human information processing. When humans process information, size is associated with importance. Larger symbols are interpreted as marking more important contacts. The association between size and importance may cause errors in judgement. Specifically, more certain contacts are perceived as the more tactically critical, which is not the intent of the size coding. The intuitive association between size and importance is not only difficult to

overcome, but attempts to do so will result in design-induced errors.

Brightness. Bright objects are interpreted as being more important than dim objects. Because of the intuitive association of brightness with importance, displaying more certain contacts with brighter symbols than less certain contacts is not an effective way to code certainty. As with size coding, the importance tactically is not always associated with the certainty that a contact has been made. The most important contacts may in fact be those that are not well detected. The goal is to provide a means to display the level of confidence without producing an associated interpretation of importance.

While it is known that operators do evaluate the strength of the detection of contacts, it is also the case that if an object is identified as a potential threat, the combat team must take action regardless of the certainty or sensor that picked up the contact. The correct level of information must be presented and it must be easily assimilated into knowledge, or the information is counter-productive.

Other means to indicate the certainty of an identification include a certainty ellipse. A brief discussion of certainty ellipses follows:

Certainty Ellipse. A certainty ellipse is an elliptical shape placed around the contact symbol. The size of the ellipse is intended to convey the certainty of the identification. Certainty ellipses carry with them the cognitive connection of size with importance, and have not been proven to be completely successful.

In Section 3.6: *MSDF Concept Proposal* the issues presented throughout this chapter have been considered.

3.4 TESTING NEW SYMBOLOGY

Before considering implementation of new symbology each option should be subjected to human-centred evaluation. A complete discussion of Human-Centered evaluation and its role in development projects is outside the scope of this project. However, a few notes are included here. Human-centred evaluation is a specialty and should be conducted by an expert in that field in order to avoid confounds, errors in design, and invalid results. The operator-testing tasks of the symbols should include recognition, matching, and recall tasks. See the following references or contact the author for more information:

- Campbell, Gweneth U. (January 1999). NORAD [North American Aerospace Defense] R/SAOC [Region/Sector Air Operations Centres] Modernization Project. Assessment of Air Defence Symbology Sets. Unger Campbell and Associates.
- Campbell, Gweneth U. and Druce, Guy L. (July 1, 1996). Assessment of Desktop Icons for Land Forces CCISs. Final Report. Contract #W8477-5-CB13/01 SV. Unger Campbell and Associates. Chief Research and Development

The human-centred testing should include scenario-based operator evaluations. In brief, scenario-based tests are conducted within the context of reasonably high-fidelity operational scenarios. The test environment should include a range of data-densities on the tactical displays and should require the operator to complete a variety of relevant operational functions. In the course of human-centred testing, all of the viable options should be evaluated. The performance from the user evaluations will reveal the options that are most likely to be successful, and the user feedback can enhance the information gathered in the performance measures. The goal is to provide the option that yields the most appropriate information in the most usable fashion. Once an option has been empirically determined to be operationally effective within the CPF CCS environment, then that option should be documented and consideration should be given to forwarding the solution to appropriate agencies for inclusion in all related style guides and symbology standards.

3.5 MSDF CONCEPT PROPOSAL

There is general agreement that the MSDF requires new symbology so that the operators are informed about the MSDF-identified contacts. In support of the COMDAT OMI Style Guide effort Dr. Gweneth Unger Campbell (Unger Campbell and Associates), created a proposal that describes potential symbology to address MSDF-identified contacts. The goal of the new symbology is not to inform the operator of the machine-calculated certainty of the contact, but instead to provide the operator with cues that help the operator make informed decisions about the ground truth.

The critical information in a data-fused display is first that the computer identified the contact and that a human operator has not confirmed the identification. This distinction is essential for a variety of reasons, not the least of which is responsibility for the mission. A second important reason for the distinction is to acknowledge and support the operators' sense of the credibility of the source. As new sensors and displays are developed the operators too develop a sense of the reliability of the new sensors. As the operators become familiar with the sensors and their outputs, the operators learn to interpret the data-fused identifications. The operators intuitively evaluate the information they receive against the ground truth. In signal detection language, the operators learn the ratios of hits, misses, and false alarms. Once they are familiar with the MSDF sensors the operators use that information to enhance their knowledge of the tactical situation.

The traditional method to display the certainty of fused data is to provide a fused picture of the computer-generated certainty calculations, as could be done with a certainty ellipse for fused data. The system could provide an amalgamated view of the certainty of the contact. The role of the operator would then be to accept or reject the fused data.

When designing display elements it is important to consider the elements in the entire context of the tactical display. The display must remain uncluttered, and the elements must be easy to interpret.

In the paragraphs below details and variations on the concept are presented. The concept introduces a supplement to the symbol set, retaining all of the current symbology, rather than a change to the current symbology. The current Naval symbology set can be used without introducing a whole new symbology language. By using the current symbology the operators are not required to learn radically new symbols nor does the symbology set become too large to manage cognitively. In the concepts presented below, the operator is given the tools to draw a conclusion about the validity and identification of a target, rather than having the MSDF algorithm draw a conclusion for the operator.

In general terms the concept is as follows (detailed versions are described in the paragraphs below): the operator is presented with the current Naval symbol for a contact, enhanced with a simple visual code that identifies the source sensor(s) for the contact. In a modified version of the symbology, the strength of the input from each source would be displayed. In either version, the operators' role would be to determine the certainty of the contact from the specific combination of sensors actually deployed. The concept presented here permits the operators to calculate certainty using their entire body of knowledge, rather than to respond to the computer's calculation of certainty. By putting the decision in the hands of the operators the decision process (supported by the display) uses the operators' knowledge of the tactical picture, the data patterns from the sensors, and the knowledge of ground truth. In order to keep information processing low, the graphic display of the information must be simple, and must be intuitive.

Presented here are initial concepts. Five versions of the concept are presented. In accordance with the goal of keeping displays simple intuitive and uncluttered, the first version of the certainty symbology proposed below is the recommended option.

The five versions described here are as follows:

- 3.5.1 **Quantitative Certainty Symbology**
- 3.5.2 **Enhanced Quantitative Certainty Symbology**
- 3.5.3 **Qualitative Certainty Symbology**
- 3.5.4 **Alphanumeric Variant of 3.5.3**
- 3.5.5 **Identified Source Certainty Symbology**

3.5.1 Quantitative Certainty Symbolology.

In the Quantitative Certainty display, a small dot for each sensor that detects a contact is displayed co-located with the current Naval symbol for the contact. Candidates for the display area include left to right across the top, or centred on each of the four sides. In the simplest version a small dot is presented at the left-most corner of a virtual square around the symbol if one sensor has picked up the target. As more sensors pick up the target more dots are displayed in a horizontal line across the top of the target.

Version 5.5.1: *Quantitative Certainty* does not provide information about which sensor is represented. The quantitative version provides a simple display of the number of sensors that have contributed to the fused interpretation of the data.

3.5.2 Enhanced Quantitative Certainty Symbolology.

In Version 3.5.2: *Enhanced Quantitative Certainty*, the display symbolology is identical to that proposed in Version 3.5.1. The enhancement is the availability of more information upon request. Details of the sensor source will be included in the tactical read-out display of the hooked track. If data blocks are provided on the tactical display (these are the details of the track such as ID and speed, displayed near the hooked track in a transparent window upon the demand of the operator) then the sensor source information can be displayed in the data block.

3.5.3 Qualitative Certainty Symbolology.

Version 3.5.3: *Qualitative Certainty* is similar to the quantitative version with the single exception that the strength of the certainty, as calculated by the system, is displayed by either the brightness or size of the dot. Brightness or size of the dot is an appropriate cue in this instance because it is associated with importance (the gestalt of the dots is a sense of volume and brightness). The increased perception of volume and brightness indicates increased certainty.

The dots are intended to be sufficiently small that the brightness of the dots will not conflict with the interpretation of the main contact symbol. If Version 3.5.3: *Qualitative Certainty* is considered, the impact of using brightness as an associated cue will require objective evaluation. A difficulty that will need to be overcome is that absolute brightness needs a visual referent in order to be interpreted correctly.

3.5.4 Alphanumeric Variant of Version 3.

A variant on Version 3.5.3: *Qualitative Certainty* is to provide a more intuitive cue as to the identity of the sensors. As an example, the initial letter of the term for the source can be displayed instead of a simple dot. An example is to display an R for Radar. This variant has consequences to the usability of the system. A letter requires far more cognitive processing, remembering, and coding than does a dot. Letters also require far more screen real estate than do dots in order to be effective. The screen real estate required for letters may clutter up the operators' tactical display. This option is not optimum unless an overwhelming advantage can be demonstrated.

3.5.5 Identified Source Certainty Symbolology.

Version 3.5.5: *Identified Source Certainty* symbolology uses location of the dot to indicate the sensors that contributed to the data. The identification of the sensor is coded by its location relative to the main contact symbol. In this more complex version, the operators will be able to determine the source of the sensor by the location of the dot relative to the track symbol. As an example, the dot in the upper left-hand corner would identify a specific sensor and a dot in the upper right-hand corner would be associated with a different sensor. The identified source certainty symbolology provides more information to the operator than the earlier versions, but that information is less intuitive and requires more training to learn and retain.

3.6 SYMBOLOGY RECOMMENDATIONS

The recommendations from this chapter are as follows:

- 3.6.1 **Assessment.** The MSDF information and knowledge requirements of the back row operators should be assessed.
- 3.6.2 **Consistency.** MSDF symbology should remain consistent with current Naval symbology.
- 3.6.3 **Sensor of Origin.** MSDF should avoid creating distinctions among symbols based on the sensor of origin unless those distinctions positively impact operations.
- 3.6.4 **Fidelity.** MSDF symbology should remain representational and simple rather than literal and detailed.
- 3.6.5 **Confirmation of Sources.** MSDF symbology should distinguish between machine-generated contact symbology and contacts that have been confirmed by human operators.
- 3.6.6 **Certainty.** MSDF symbology should contain enough information to permit the operators to confirm judgments of the certainty of the contact.
- 3.6.7 **Raw Data.** Raw (or partially processed) data from the sensors should be available in near real-time to the operators so that they can enhance their knowledge of the contact.
- 3.6.8 **Evaluations.** MSDF symbology, as with all new symbology and display enhancements, should be evaluated for its impact on operations.
- 3.6.9 **Design of the Evaluations.** A specialist in human-centred evaluation procedures should conduct evaluations of all new symbology.
- 3.6.10 **Starting Point.** Consider using the proposal presented in Section 3.6.1 as a starting point for development.

4.0

DISCUSSION OF IDENTIFIED HUMAN FACTORS AND USABILITY ISSUES IN THE HALIFAX-CLASS CANADIAN PATROL FRIGATE

4.1 INTRODUCTION

As part of the preparation for creating a Canadian COMDAT Style Guide Dr. Gweneth Unger Campbell was permitted to observe the operation of the current Halifax-class CPF Command and Control System (CCS) while at sea during a training exercise. The operator roles of interest for the COMDAT project are the Operations Room Officer (ORO) the Surface Warfare Controller (SWC) and the Anti-Submarine Warfare Controller (ASWC). These operator roles were observed during the five-day exercise. Dr. Campbell was able both to observe the operators as they conducted their tasks and to ask the operators for details of how the tasks were conducted, the aim of the tasks, cognitive requirements, and a variety of other usability and style-related questions.

This chapter is divided into four sections as follows:

5.3 INTRODUCTION

5.4 CONTENT OF THE USABILITY REPORT

5.5 IMPACT OF IDENTIFYING USABILITY ISSUES

5.6 GUIDANCE FOR DEVELOPERS

4.2 CONTENT OF THE HALIFAX-CLASS CANADIAN PATROL FRIGATES: COMMAND AND CONTROL USABILITY RECOMMENDATIONS REPORT

The *Halifax-Class Canadian Patrol Frigates: Command and Control Usability Recommendations* report does not include basic Human Factors design principles nor style guide issues but is instead a collection of observations that are specific to the Halifax-class CPF CCS or that should be addressed in system upgrades.

The *Halifax-Class Canadian Patrol Frigates: Command and Control Usability Recommendations* report is divided into three sections and three annexes as follows:

- *Section 1.0: Introduction.* Section 1.0 contains an introduction to the report.
- *Section 2.0: Overview.* Section 2.0 contains a high level summary of the highlights of the report.
- *Section 3.0: Summary of Observations and Recommendations.* Section 3.0 contains a summary table of the 100 observations and recommendations.
- *Annex I: Questionnaire Results.* Annex I presents the detailed results of usability questionnaires completed by the operators. The data include the demographics of the personnel interviewed as well as responses to both scaled and open-ended questionnaire items.
- *Annex II: Observations and Recommendations.* Annex II contains a complete list of the observations and recommendations resulting from the observation of operations aboard HMCS Ottawa. A discussion of each item is included.
- *Annex III: Acronym List.* Annex III contains a list of the acronyms used in the report.

4.3 IMPACT OF IDENTIFYING USABILITY ISSUES.

The impact of identifying usability issues for the COMDAT OMI style guide is two-fold as follows:

- 4.3.1 Understanding the Mission Context.** An understanding of the actual user tasks and missions focuses the style guide. Without an understanding in some detail of the missions of the operators the style guide would become too general to be appropriate for Canadian operations. Examples include the detailed guidance provided in the COMDAT OMI Style Guide for real-time access to safety-critical functions. An understanding of the working environment, conditions, and missions of the operators is necessary for OMI guidance that supports the importance of speedy real-time access to specific functions.
- 4.3.2 Ensuring Suitability for Maritime Operations.** Once the usability issues are identified those options that are not suitable to Maritime operations can be addressed in the style guide. By so doing guidance is avoided that would be inappropriate for a Maritime application. Examples include the style guidance for general windows applications that the windows must be able to be closed or minimized. While such guidance is appropriate for some applications it is not universally appropriate for CPF command and control operations. Accordingly, the COMDAT style guide specifies that certain windows (such as the Tactical Display) cannot be closed or minimized.

4.4 GUIDANCE FOR DEVELOPERS

In addition to the immediate impact on the COMDAT OMI Style Guide as it was developed, the identification of usability issues provides guidance for developers who are implementing COMDAT applications or upgrading the current CCS.

- 4.4.1 Information from Questionnaires.** The *Halifax-Class Canadian Patrol Frigates: Command and Control Usability Recommendations* report includes a discussion of results from a questionnaire administered to operators in each of the three identified roles. The demographics (age, rank, experience, etc.) of the operators are identified as well as their collective answers to both scaled and open-ended questions. The answers to questions regarding what these operators like most and least about the Halifax-class CCS provide usability context for developers of Naval command and control systems. The answers also provide a sense of the operators' priorities. These identified priorities should be validated and reflected in CCS upgrades.
- 4.4.2 Questionnaire Responses Regarding Decision Aids and Enhancements.** Of immediate relevance to the developers in the COMDAT OMI project are the operators' answers to an open-ended question regarding decision aids and other enhancements. While it is important to be aware that the operators are not developers and as such do not have professional knowledge about what is technically possible, their answers do provide direction regarding the operators' priorities. These priorities should be addressed in the COMDAT OMI development.
- 4.4.3 Tracking the Usability of the COMDAT OMIs.** Questions regarding the usability of the current Halifax-class CPF CCS are included in the report. The answers to these questions can be used as baseline information to evaluate the COMDAT OMI development. The COMDAT OMI development is intended to support the conduct of the operations. In order to do so effectively the COMDAT capabilities should enhance the operators' ability to use the system, find the features needed, and understand the information presented in the displays. All of these capabilities are addressed in the scaled questions asked of the operators. COMDAT OMI displays can be subjected to the same questionnaire as part of the development process. The usability trends can then be tracked and the information gathered can be used to direct development. The COMDAT OMI design should enhance, or at least not reduce, the level of user satisfaction on these measures.

4.4.4 Links Between, Usability, Requirements, and Design. The *Halifax-Class Canadian Patrol Frigates: Command and Control Usability Recommendations* report includes 100 identified usability issues. The links between identified usability issues and the COMDAT OMI styles range from requirements definition to direct guidance for the COMDAT OMI styles. For example, a requirement may be the display of the date/time group. The style guidance defines the display parameters for the date/time group. In other cases the usability recommendations identifies a concept that may or not be realized in the COMDAT development. An example of the latter is the concept of the utility of a large screen display. In command and control centres where briefing of multiple operators is required, operators indicate the necessity for a means to convey the briefing material effectively. While support for briefings may not be a COMDAT requirement, the concept is important to the entire working environment and should be considered as part of the overall operational requirements.

5.0

OPERATOR-MACHINE INTERFACE (OMI) STUDY: ENHANCEMENTS AND MAKING THE DOCUMENTS AVAILABLE ON THE WORLD WIDE WEB

5.1 INTRODUCTION

Task 3.1.12 of the OMI Study includes the preparation and delivery of a report on how the material in the COMDAT OMI Style Guide can be made available on the World Wide Web.

In order to maximize the usability of the document the best way to post the document is to provide several options depending on how the viewer prefers to use the document. The options are discussed in this chapter and the recommended course is suggested.

This chapter also discusses enhancements to the document.

This chapter includes the following sections:

- 5.1 INTRODUCTION**
- 5.2 REQUIREMENTS AND ASSUMPTIONS**
- 5.3 POSTING AND CONVERSION OPTIONS**
- 5.4 ENHANCEMENTS TO IMPROVE USABILITY**
- 5.5 CORPORATE CAPABILITIES**
- 5.6 CONCLUSION AND RECOMMENDATIONS**

5.2 REQUIREMENTS AND ASSUMPTIONS

5.2.1 **Assumptions.** The World Wide Web solutions discussed in this chapter assume that an appropriate website on which to post the OMI Style Guide is already created and is in operation.

5.2.2 **Security.** Regardless of the method used to post the material on the World Wide Web, appropriate security would have to be implemented to ensure that only authorized users could modify the document.

5.2.3 **Website Modifications.** The document will be posted on an existing Website. The existing Website will require changes, and possibly notification to subscribers of the new posting, so that users will be aware that the new information is available. Depending on the structure of the site the modifications, or notification of the new document, will include a minimum of one or more of the following:

- adding the title of the document to an existing list of posted documents
- changing the menus of an existing web site
- adding key words so that searches will return the filename
- notifying subscribers of a new posting
- other site-specific changes

5.2.4 **Document Location.** The prospective users will need to be able to locate the Website and the document by using the most popular search engines. Appropriate keywords must be defined and implemented in the Website metatags.

5.3 POSTING OPTIONS

- 5.3.1 **Direct Posting as a Microsoft® Word Document.** The simplest version of posting the OMI Style Guide to the World Wide Web is to post the document as a Microsoft® Word document on the appropriate sites. This options is available but is not recommended.

Direct posting is the most cost-effective method to implement, but does not provide good service to the users in the sense of access to the report. In order to read a downloaded version of the report the users would require the appropriate Microsoft software in the appropriate version. The posting would be time-limited because it would be restricted to specific versions of MS Word and any future versions only as long as they are backward-compatible. Macintosh users might not be able to open without unacceptable corruption or might not be able to open the file at all.

The users would be limited to either reading the file on-screen or, if they have access to appropriate software, to downloading the file. The users would not be able to search effectively for keywords, link to related documents, or link from the table of contents to the section indicated therein.

- 5.3.2 HTML Conversion.** The report can be converted into HyperText Markup Language (HTML) for on-line viewing.

The HTML format is the preferred method for online viewing. By converting the document to HTML and providing appropriate links, the users will be able to access areas of interest within the document. The users will also be able to link to source material and reference documents if those materials are available on the Internet.

Posting the document on the Website as an HTML file requires that the following conversions, links, and maintenance be addressed.

- 5.3.2.1 Conversion.** Converting the document to HTML, defining and embedding the appropriate links as required.

- 5.3.2.2 Relative Links.** Relative links are links that are internal to the COMDAT OMI Style Guide. Examples include links to specific sections within the document. These should be defined and implemented.

- 5.3.2.3 Absolute Links.** Absolute links are links that give the entire HyperText Transfer Protocol (HTTP) Uniform Resource Locator (URL) address and link to pages that are not contained on the Website. Absolute links are invaluable for the users who wish to access related material that is available on other Websites (examples may include cited source documents), and so should be included in the HTML document.

- 5.3.2.4 Maintenance.** If the absolute links are implemented then it is necessary also to have a web-master or equivalent who will be responsible for maintaining the links. The usability literature makes it clear that linking to sites that are under construction or otherwise not actually available must be avoided.

- 5.3.2.5 MS Word Conversion Software.** It is generally thought that the MS Word conversion capability should not be used to generate the HTML code due to concerns about the MS Word Conversion code. The choice of appropriate tools is the responsibility of the conversion contractor.

- 5.3.2.6 Size of the File.** Due to the size of the document it would be inappropriate to post it as a single html file. If an html file is posted for the purposes of on-line viewing Unger Campbell recommends that the document be broken into chapters.

5.3.3 PDF Conversion

5.3.3.1 PDF Conversion. For the purposes of printing the file the best format is a high resolution pdf format.

5.3.3.2 Acrobat Reader. The pdf format can be downloaded and opened with Adobe Acrobat Reader software. Adobe Acrobat Reader is provided free by Adobe and is readily available regardless of the platform being used.

5.3.3.3 Editing. When the pdf version is posted, the users will not be able to inadvertently or purposely edit the contents and so the document's integrity will be preserved.

5.3.3.4 Direct Access to Contents. Other features of the pdf format will also benefit the users. These features include the generation of a menu for the table of contents so that each section can be readily accessed.

5.3.3.5 Resolution. If the document is posted only in pdf, and is not also posted in html, then two versions should be available: low resolution for screen viewing and high resolution for printing.

5.3.3.6 HTML Support. If the document is posted only in pdf format then document should have an html introduction with appropriate links.

5.4 ENHANCEMENTS TO IMPROVE USABILITY

- 5.4.1 **Index.** For the purposes of using the printed document effectively the COMDAT OMI Style Guide should be enhanced by the addition of a thoroughly cross-referenced index. If such an index is provided the user will be able to find the information of interest without the necessity to access the online version separately.
- 5.4.2 **Illustrative Graphics.** The COMDAT OMI Style Guide will benefit from the addition of illustrative graphics. While these were beyond the scope of the current project they should be considered in the immediate future. The COMDAT OMI Style Guide provides direction for the design of visual displays and would benefit from the addition of graphics that illustrate the various elements of the guidance. Examples include illustrations of menus, layout, and design of buttons.
- 5.4.3 **Colour Guidance.** The COMDAT OMI Style Guide will benefit from added guidance on the use of colour, particularly regarding the dark-operations room environment and under dark-adaptation conditions.
- 5.4.4 **Positive Solutions.** As successful design solutions are developed, the COMDAT OMI Style Guide can be enhanced to include descriptions and graphic illustrations. By including successful implementations and design solutions those solutions will be shared among the Maritime Command and Control software developers. Sharing the information will contribute both to interoperability and transfer of training across systems. The development costs will be reduced due to the ability to re-use successful design solutions. As these solutions are achieved the altered COMDAT OMMI Style Guide can be edited, as appropriate, and will provide a core reference resource for Maritime Command and Control software solutions.
- 5.4.5 **Design of the World Wide Web Pages.** The posting of the document should be treated as any usability issue. Issues to be considered include who the users are, what level of skills they can be expected to have, etc. Part of that analysis is to determine how to best sub-divide the report and what links will be most effective. The design should include at minimum links that permit easy navigation through the document such as next/previous/top of page/top of chapter etc. The design should also provide appropriate key word search tools.

5.5 CORPORATE CAPABILITIES

Unger Campbell has available capable Computer Graphics personnel, Computer Scientists, and senior Human Factors and Usability staff; the latter in the person of Dr. Campbell. Unger Campbell has the capability to implement the recommendations discussed. Unger Campbell's capabilities include, but are not limited to, the following:

- Create the conversions of the document
- Familiarity with the domain and the document
- Design the appropriate links, indices, frames, and sub-divisions for the document
- Implement the posting
- Generate the appropriate illustrative graphics
- Provide further guidance regarding the use of colour
- Evaluate and add new solutions to the COMDAT OMI Guide

Each of these can be completed in a timely and efficient manner.

5.5 CONCLUSION AND RECOMMENDATIONS

- 5.6.1 **Post Two Versions of the Document.** The users of the document will be best served if the file is posted in two separate formats: html for on-line viewing and pdf (high resolution) for printing. The document should be broken into manageable sections and an html page should be generated that contains an introduction/overview and links to each section.
- 5.6.2 **Printing Options.** The users should be provided with the options to print the entire document with one command, or print selected sections or parts of the document.
- 5.6.3 **Printed Index.** The document should be enhanced by the addition of an index for ease of using the printed version.
- 5.6.4 **Illustrative Graphics.** Where appropriate, the document should be enhanced by the addition of illustrative graphics that support the guidance in the text.
- 5.6.5 **Conversion Tools.** The MS Word capability should not be used to generate the pdf conversion. The choice of an appropriate software tool can be at the discretion of the contractor, with agreement between the contractor and DCIEM.
- 5.6.6 **Design of the World Wide Web version of the Document.** The posted version of the document should include appropriate links, navigation aids, and division of the document into sections; each of these will make the document easier to use.
- 5.6.7 **Design of the Content and Layout of the Environment.** The design of the World Wide Web version of the document should be treated as a user interface design and should reflect the users requirements as well as provide appropriate navigation links and search tools.
- 5.6.8 **Additional Content.** The document should be edited to provide further guidance specifically regarding the use of colour in dark-adaptation environments and regarding the inclusion of successful design solutions.
- 5.6.9 **Capabilities.** Unger Campbell and Associates is familiar with the document and has the capability to implement the work in a timely and efficient manner.

DOCUMENT CONTROL DATA SHEET		
1a PERFORMING AGENCY Unger Campbell and Associates, 11724 Alderwood Crescent, Delta, B.C. V4E 3E6		2 SECURITY CLASSIFICATION UNCLASSIFIED Unlimited distribution -
1b. PUBLISHING AGENCY DCIEM		
3. TITLE (U) Command Decision Aiding Technology (COMDAT) Operator-Machine Interface (OMI) Study: Version 1.0		
4 AUTHORS Gweneth Unger Campbell I. Campbell		
5 DATE OF PUBLICATION October 10 , 2001		6. NO. OF PAGES 53
7 DESCRIPTIVE NOTES 		
8 SPONSORING/MONITORING/CONTRACTING/TASKING AGENCY Sponsoring Agency Monitoring Agency Contracting Agency : DCIEM Tasking Agency		
9 ORIGINATORS DOCUMENT NO. Contract Report CR 2001-172	10. CONTRACT GRANT AND/OR PROJECT NO PWGSC Contract Number: W7711-007659/001/TOR	11 OTHER DOCUMENT NOS
12. DOCUMENT RELEASABILITY Unlimited distribution		
13. DOCUMENT ANNOUNCEMENT Unlimited announcement		

14. ABSTRACT

(U) This report includes supplemental and background material related to the development of the COMDAT OMI Style Guide for Navy Command and Control operations. The material is presented here in five chapters. Three chapters comprise background materials as follows: the purpose and outline of the COMDAT OMI Style Guide, a literature review, and a discussion of making the documents available on the World Wide Web. The remaining two chapters present respectively a discussion of Naval symbology and a discussion of identified Human Factors and Usability issues in specific command and control functions of a Halifax-Class Canadian Patrol Frigate (CPF).

15. KEYWORDS, DESCRIPTORS or IDENTIFIERS

(U) OMI; operator machine interface; human factors; naval systems; COMDAT; guidelines; symbology; command and control; world wide web



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TITLE: Command Decision Aiding Technology (COMDAT) Operator-Machine Interface (OMI) study: version 1.0

PERSONAL AUTHOR: Campbell, G.U.; Campbell, I.

CORPORATE AUTHOR: Defence and Civil Inst of Environmental
Medicine, Downsview ONT (CAN)

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Il y a un résumé français ici.

DESCRIPTORS: Decision making; Information systems; Naval operations; Frigates; Human factors engineering; Job analysis; Mission profiles; Models; Operational effectiveness; Operators (personnel); Tactical data systems; Task analysis; Man computer interface; Integrated systems; Canadian Patrol Frigate (CPF)

IDENTIFIERS: COMDAT (Command Decision Aid Technology) Project; Decision support systems; Operator machine interface; Design guidelines; OMI (operator-machine interface); Style guide; Symbology; System design

REPORT NUMBER: DCIEM-
CR-2001-172; Contractor
Report

REPORT DATE:
10 Oct 2001

NUMBER OF PAGES : 53

DRDKIM N°: CA020634

CANDIS N°:
517347

Format(s): Hardcopy; Document
Image stored on Optical Disk

Date modified: 2005-04-05

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